Chapter I
CHAPTER 1
Introduction
1.1 Introduction

Cellular manufacturing system (CMS) is one of the modern manufacturing techniques. Cellular manufacturing strives to attain the benefits of a product oriented layout for medium variety, medium volume production environment by processing a family of parts on a group of machines. CMS provides flexibility as a means for maintaining a desired level of productivity. In CMS the manufacturing system is decomposed into a set of sub-manufacturing systems, and a kind of linkage exists between these sub-systems (cells) in terms of intercellular movement. Attainment of full benefits of CMS is possible only with efficient production control activities. The application of CMS is wide in the production of automotive components. Burbidge (1979) defined Group Technology (GT) as an approach to the optimization of work in which the organizational production units are relatively independent groups, each group responsible for the production of a given family of products. Cellular manufacturing concept has been applied in many manufacturing environments and can achieve significant benefits. Manufacturing units surveyed by researchers have witnessed the following results:

- Set-up time reduction
- Work-in-process inventory reduction
- Material handling cost reduction
- Improvement in quality
- Improvement in material flow
- Improvement in machine utilization
- Improvement in space utilization
• Improvement in employee morale

Present day research concerns with the development of concepts and techniques for repetitive manufacturing operations. Cellular manufacturing and flexible manufacturing systems are the prime process technologies for repetitive manufacturing.

Cellular manufacturing systems are finding wider adoption in industries. The problem of cell formation remains critical. This is to be attended from many angles viz. formation for grouping efficacy, formation for machine utilization, formation for ease of implementation etc. Moreover, the size of the cell and the number of cells are some of the factors to be considered in designing a CMS. This indicates the requirement for multiple solutions for selection based on the criteria. In addition, the part families are required to be divided into sub-families for ease of scheduling taking the similarity of parts/setup. When the given set of jobs are classified into cells the problem of scheduling becomes easier as there are only fewer jobs in a cell compared to the state prior to cell formation. The existence of job shops in cellular manufacturing environment calls for job shop scheduling procedures. In multi-operation shops jobs often have different routes. This environment is referred to as job shop, which is a generalization of a flow shop. Repetitive manufacturing systems need methods for better and faster solutions to their scheduling requirement. This led to the attempt for solutions of cell formation and scheduling through non-traditional optimization algorithms. The given set of jobs is to be grouped into families of parts and groups of machines. The cells so formed will be treated for scheduling considering the type of production as job shop. Thus the work concentrates on finding a method for cell formation and applying non-traditional optimization techniques for the scheduling of jobs in the cells

1.2 Cellular manufacturing systems and scheduling – a survey

Cellular manufacturing systems are finding increased applications in industries
producing components in batches. It is applied in a large way in advanced countries and is being applied in advancing countries. The sudden switching over from conventional systems to CMS is not immediately accepted by the management of industries and the employees as well. The main problem of CMS is that of cell formation. Some of the important literature available on cell formation has been discussed in Chapter 2. The literature on Job shop scheduling problem (JSSP) and various methods of solving the problem have also been presented in Chapter 2. Besides, literatures on the representations schemes for job shop scheduling problems and on a host of crossover/reordering operators of GA are included in the above chapter. Finally, the details of earlier works on application of Simulated Annealing (SA) for scheduling problems are presented in Chapter 2.

1.3 Cell formation method

Chapter 3 deals with the proposed cell formation method. Cellular Manufacturing is an application of GT philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and manufacturing. An attempt has been made to form part families and cell formation using fuzzy logic. Cosine amplitude method (Timothy Ross, 1997) has been used to find similarity co-efficient between jobs and machines and the max-min composition operation has been used to form part families and machine groups. The advantage of the method is that it gives a set of solutions with varying number of families/groups. The method has been demonstrated with a typical problem. The results obtained with the proposed method for a set of well known problems are also presented.

1.4 Scheduling with genetic algorithm for penalty minimization under CMS

In order to obtain the full benefit of the GT, it is important that cell design should be coupled with sound system of production planning and control. Group scheduling requires
that all parts in a family are processed in the same cell and there is no intercellular move. In a typical CMS environment it is difficult to form independent manufacturing cells and normally there are exceptional components requiring inter-cellular movement of parts. Analysis on the similarity of components in cells has clearly shown the existence of job shop situation in cells. A job shop environment involving penalty cost has been taken and cells have been formed. After forming the machine cells, three priority indices have been applied to schedule the parts for minimum penalty amount and a GA based heuristic has also been applied for scheduling and the results compared. This analysis has been presented in Chapter 4.

1.5 Representation scheme for job shop scheduling problems

With more and more components falling in a family the cells tend to become job shop cells. Considering the type of production as job shop takes care of flow shop production also as flow shop is a case of job shop. The various representation schemes available for JSSP perform differently when applied with GA. An attempt has been made through GA to solve JSSP with a proposed method of representation and schedule deduction with the makespan objective. Computational experiments of this attempt have yielded better solutions coupled with appreciable reduction in computer processing time. The proposed method has been compared with two available representation schemes for a set of benchmark problems, in Chapter 5.

1.6 Enhancement of performance of GA through a typical operator

The performance of GA depends, largely, on the performance of the crossover operator used (Gen and Cheng, 1997). An approach through GA to solve JSSP using inversion operator has been tried, with makespan objective. Simulation of the application of GA with the inversion operator on a set of benchmark problems shows the better performance
of the operator in respect of solutions and computer processing time compared to solutions with Generalized Position operator. The solutions of a set of problems solved using Generalized Position operator have been reported in a technical paper. The solutions have been compared with the solutions produced using inversion operator for the same set of problems and given in Chapter 5.

1.7 Scheduling through Simulated Annealing

Job shop scheduling problems have been solved using various techniques applying different scheduling rules, heuristics, Neural network, Genetic algorithm and methods like SA and Tabu search. In many reports it is noted that SA algorithm performs better. An attempt has been made to solve the JSSP with three representation schemes using Simulated Annealing. The results of SA algorithm have been compared with the results obtained using GA. This comparison is exhibited in Chapter 6.

1.8 Summary

The summary of the results obtained through the proposed method, in forming cells, has been presented. The application of genetic algorithm for optimization of scheduling in job shops under cellular manufacturing environment has been discussed. The details of application of GA for JSSP with different representation schemes and genetic operators and their relative performance have also been incorporated. The performance of simulated annealing in solving JSSP has been analyzed. The work concentrates on developing methods, which will be useful to both practitioners and academicians alike. The data offered by benchmark problems are comparable with practical data sets. Methods developed may be applied to real life situations, which will be taken up while furthering the work.